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ROMANCE IN SCIENCE

An Experimental Course Offered by a Department of Mathematics[1]

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At the beginning of the second semester of this year we opened a two-hour course, popularly called " Browse," with a description of a sleek, cream-colored Jersey, standing in deep grass and pausing, after a lucious bite, to gaze meditatively over the landscape. Before the spring vacation, in that same course, I gave an examination on the content of the Einstein Theory and its relation to the Newtonian Theory. Why, how, and with what results I made that transition are the subjects of this paper.

Two years ago at a section meeting of the Association, Dr. Slaught urged that, since we mathematicians had an interesting subject, we might profitably take time occasionally to show the students how interesting it was. This, combined with a previously observed fact that the survey course of English literature not infrequently left the science student with either a distaste for reading of any sort, or with the expectation of usually being bored by it, galvanized me into making some more definite observations, with the purpose of getting a solution for the pedagogical problem presented.

The results of these observations on my own classes are as follows: first, that a liking for reading can be aroused in the scientific student by references to scientific literature, not to text-books; second, that interest in scientific ideas can be aroused in the arts student by relating mathematics to other fields of knowledge through essays; third, that a greater lack of scientific literary background than was usual in the preceding generation exists now among all types of students.

With these results in mind I announced the new course under the double title "The Romance of Science or The Grammar of Science, Whichever You Wish," to show the arts student that science had the imaginative quality which she so enjoyed, and to show the science student that poetry, fiction and opinions did not constitute the whole of the world's literature.

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[1] This paper was read before the meeting of the Illinois section of the Mathematical Association, April 28, 1922.

In the college catalogue the course is described as being " Some Literature of Science," a somewhat commonplace title, which would not attract too much attention on the part of the ultra-conservatives in scientific teaching. " Browse " is the unconventional nickname which was given the course because of its appropriateness to the purpose without having the unfortunate connotation for the student that words such as " Meditate " might have, for no American student is willing to acknowledge that she thinks, much less meditates.

The prerequisite for the course is Freshman Mathematics or enrollment in that course with a grade of " B " for the first semester. This secures some knowledge of analytical geometry, limits and differentiation on the part of all, although it is a very elementary knowledge.

The main topics of the course are six in number. The first was the scientific method, ancient and modern. This was illustrated by the various theories of the earth's motions, which led to Newton's Law of Gravitation, and which included a study of hypothesis and conclusion. The second was dimensionality in algebra and geometry, including, of course, the fourth dimension; and the third, the distinction between Euclidean and Non-Euclidean geometries. These two involved a discussion of some popular fallacies and also of the scientist's point of view, when he chooses the most convenient mathematical hypothesis from several, any one of which is equally logical. The fourth topic was the Einstein Theory, which involved no proof, but included a description of the theory and of its relation to the Newtonian Theory, a statement of the mathematical and experimental verifications up to date, and the present status of the theory in the scientific field. The fifth topic, which I am now working on, is applications of mathematics in other fields than that of physics. This includes a discussion of the human value of mathematical thinking and the place held by mathematics in civilization. The last subject will be some of the famous concepts of mathematics, such as number, limit, function, group.

In addition to the main fields of investigation indicated above, side excursions into the domains of art, astronomy, biology, chemistry, mathematics, medicine and physics are made. This is possible because of the method of conducting the course. Once a week references and lectures are given on one of the main topics. Supplementary reading of two kinds are assigned over a considerable period of time. Each student chooses one long or two short books for her " browsing " throughout the semester. She is guided by only her own taste except that her selection must be made from the official bibliography of the course. In addition, essays or short books are so assigned that each student will have read by the end of the semester one or more pieces of good literature in each of five scientific fields not covered by her " browse " book. A second class appointment is devoted to discussions or speeches or papers. The last two are sometimes expository and sometimes critical.

Some of the more obvious results of the course can be listed as follows:

1. An answer to the student's query, " Why study mathematics? "

2. An increased vocabulary for all and a remarkable improvement in correctness of speech and flow of language for the science student.

3. A rebutal of the statements, " Books Are Dull," and " Science Is Dull," made by the science and arts students respectively.

4. An extension of the intellectual horizon and a consequent increase in intellectual tolerance.

5. A knowledge of a scientific but literary reading list.

6. A knowledge of some fundamental concepts of mathematics, the lack of which Henry Adams so bewails.

7. A knowledge of some of the modern developments of mathematics. After further experimentation it is probable that a coefficient can be attached to some of these results.

The less obvious results aimed at by the course, which I cannot now measure and perhaps may never be able to measure, are a permanent taste for reading and even more for " browsing." The necessity of " browsing " is rather well expressed by Arnold Bennett in the last chapter of his little book called *Literary Taste, How to Form It.* I shall quote a little from this chapter called "Mental Stocktaking" in the hope that you will be lured on to read more. "The superlative cause of disastrous stocktaking remains. * * * It consists in the absence of meditation. * * * if a man does not spend at least as much time in actively and definitely thinking about what he has read as he has spent in reading, he is simply insulting his author. * * * reading with him is a pleasant pastime and nothing else. This is a distressing fact. * * * It is distressing for the reason that meditation is not a popular exercise. If a friend asks you what you did last night, you may answer, "I was reading," and he will be impressed and you will be proud. But if you answer, "I was meditating," he will have a tendency to smile and you will have a tendency to blush. I know this. * * * (I cannot offer any explanation). But it does not shake my conviction that the absence of meditation is the main origin of disappointing stocktakings." Most of us who teach will agree with Mr. Bennett.

Although the results from the course have been very satisfactory, there are some difficulties and dangers inherent in the very character of the course. Depth may be sacrificed to breadth. Confusion may be caused by the introduction of too many ideas, in which event it would have one of the disadvantages of the literature course whose effect upon science students is so often to be depreciated. Idle dreaming may be cultivated instead of leisurely thinking. But it is not very difficult to avoid these dangers, and they are offset somewhat by the flexibility of the course and its very general appeal, for it can be given each year with variations, can be adapted to all classes of students by means of the supplementary reading, can be used to eliminate popular fallacies concerning the study, content and applications of mathematics, and to stimulate interest in all the sciences. It has certainly proved successful if the students' interest, the extraordinary improvement shown by some, and the very high quality of work attained by others can be used as criteria.

The reading list which follows contains not necessarily the

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[1] Many have asked if it is possible to work up a "Browse" course while it is being given. It seems to me to be impossible if the lectures are to be well done. A year's reading and listening to many lectures were needed to produce the two lectures on the Einstein Theory which were given so as to convey a real meaning to the class with only the preparations mentioned in the paper. A superficial knowledge of any of the subjects presented in the courses would seem to me to be fatal to the scholarship of the course.

—B. I. M.

best books which could be found anywhere, but the best which were accessible in our library this semester. Moreover, it does not aim to be exhaustive, but suggestive.

READING LIST FOR "BROWSING"

In the Spring of 1922

Mathematics XVIII (speaking technically)

ASTRONOMY (A)

1. *Astronomy.* Hinks. This is an elementary, nontechnical little book, written in a somewhat commonplace style and addressed to any man.
2. *Origin of the Earth.* Chamberlain. This is well written, presents interesting facts and theories, is trustworthy scientifically and is addressed to an audience of intelligence but having little technical training. This was apparently the source of Prof. Salisbury's lecture last year.
3. *The Sun.* Sampson. This is one of the set of small, scientific books, written in a good and interesting style, for popular reading, where popular is used in the best sense of the term. They require thinking, but not too much; they are printed very clearly and are easy to hold. In fact their advantages are many, but the shade of their binding, an unbelieveable shade of pink, is somewhat wearing.
4. *The Earth.* Poynting. This is another of the pink series.

ART AND MUSIC (AM.)

1. *Curves of Life.* Cook. This is a large, well illustrated book giving illustrations of some mathematical curves, drawn from the field of biology, art, etc. Much of it can be read by freshmen.
2. *Physical Basis of Music.* Wood. This is one of the best of the pink series. There is little in it that is not very enjoyable.

CHEMISTRY (C)

1. *Creative Chemistry.* Slosson. This is so popularly written that it gives incorrect scientific ideas by the assignment of the powers to feel and to will to inanimate objects. The Egyptians of the Pharohs' times would probably have approved of it. Its facts however are trustworthy.

BIOLOGY (B)

1. *Descent of Man.* Darwin. Darwin needs no introduction. You might read it and find that he did not say what he is frequently said to have said.
2. *Origin of Species.* Darwin. This proved to be very delightful reading one summer, spent in the mountains. It served as a transition from the writing of a mathematical dissertation to a "Sherlock Holmes" story.
3. *Living Plants.* Ganong. Such an artistic piece of scientific writing is rarely seen in these days of industrial science, except in mathematics. Ganong's book is as scholarly as it is interesting, as clear in its style as in its type.
4. *Life of the Spider.* Fabre. I have not read it but know it by reputation.
5. *Heredity.* Doncaster. This belongs to the pink series.
6. *Coming of Evolution.* Judd. This belongs to the pink series.
7. *Harvard Classics No. 38.* Harvey, Jenner, Pasteur, etc.

D

(This includes those books which are different or impossible to classify.)

1. *Harvard Classics No. 30.* Physics, chemistry, astronomy, geology. Faraday, Helmholtz, Kelvin, Newcomb, Geikie.

2. *Harvard Classics No. 33.* Physiology, medicine, surgery, geology. Harvey, Jenner, Lister, Pasteur.
3. *Harvard Classics No. 29.* The Voyage of the Beagle. Darwin.
4. *Discourses. Biological and Geological Essays.* Huxley.
5. *The Forest.* S. E. White. This is not scientific but it is a well written description.
6. *Jungle Peace.* Beebe. This is a charming piece of writing in the familiar essay style, and about such interesting things, that one lingers in reading in order to prolong the pleasure.
7. *Science and the Nation.*
9. *Realities of Modern Science.* Mills. The style is clear, but commonplace. The facts presented are interesting and readily understood. The book gives one quite a good idea of the scientific method.
10. *Outlook for Research and Invention.* Hopkins.
11. *Grammar of Science.* Pearson. The first part is interesting, the middle rather dull, the last part somewhat interesting.
12. *Education of Henry Adams.*

GEOLOGY (G)

1. *Earth Features.* Hobbs. This is addressed to a non-specialized intelligent reader. The illustrations are drawn from the United States, especially the north and west.
2. *Physiography.* Salisbury. This is long but interesting.
3. *Geology.* Lyell. This is old but interesting.

MATHEMATICS (M)

1. *Flatland.* A Square. This small book is useful rather than beautiful, but it is amusing and stimulating, if read with care at the beginning, and glanced at casually towards the end. It is easy to understand and yet gives the idea of dimension in space so that it can be applied.
2. *John Napier and the Invention of Logarithms.* Hobson. This is a half hour's reading about an instrument all Rockford graduates have used.
3. *Number System in Algebra.* Fine. This is interestingly written and not hard to read. It deals with that familiar but little understood thing called numbers and tells how they came to be.
4. *Study and Difficulties of Mathematics.* De Morgan. This is pleasant reading. It is one of the books bound in red.
5. *Mathematical Recreations.* Ball. This is full of games and puzzles as well as of other things. It is something of a scrap book.
6. *Mathematical Essays.* Schubert. If you enjoy the somewhat serious essay as a form of literature, you will probably enjoy some of these.
7. *Memorabilia Mathematica.* Mortiz. If you want an epigram or a definition, a topic for a paper or a proof of the diversities of men's ideas, read a few bits here and there. The book is a collection of notable sayings and writings either by or about either Mathematics or mathematicians.
8. *Human Worth of Rigorous Thinking.* Keyser. This is a collection of essays and lectures. Numbers I-VIII, XIV, XV are of general cultural value. The style is excellent and the ideas are sometimes interesting and sometimes inspiring.
9. *Fundamental Concepts of Algebra and Geometry.* Young. This is non-technical in that it assumes no knowledge of mathematics beyond elementary high school algebra and geometry. It is a series of lectures addressed to an audience interested in mathematics.
10. *Foundations of Geometry.* Hilbert. This is perhaps the most polished expression and the most scholarly treatment of the subject that has ever been written.

11. *Fundamental Concepts of Modern Mathematics.* Richardson and Landis. This is one of the disappointments of this generation. Its mathematics cannot be trusted.
12. *Philosophy of Mathematics.* Shaw.
13. *Space and Time.* Schick. This gives Einstein's theory, omitting the mathematical proofs.
14. *Organization of Thought.* Whitehead. This is more interesting than 15 both in style and content. Chapters I, II, VI, VII, VIII are perhaps the best. I read them with pleasure when sitting in the lobby of the Auditorium Hotel, where one may while away many an hour, musing over a book of this type and collecting data on human nature. It is not a book to hurry through, yet it is not so profound as to require one's study for its perusal. Perhaps this is because it consists of a series of lectures originally addressed to an attentive audience but one which was enjoying a vacation from routine duties. It is non-technical.
15. *Principles of Natural Knowledge.* Whitehead. This is an "enquiry". It has a most interesting origin you will find, if you read the introduction. The book is concerned with theories of the nature of matter, and the ultimate data of matter, the relation of geometry to science, the effects of the theories of relativity. If you think you know all about lines and points, read and be disillusioned.
16. *Foundations of Science.* Poincare. This requires maturity of mind, not a specialist's training. Remember it, so that when you reach the point where much that you read seems commonplace, because of its familiarity, and you really have the thrill of coming in contact with a new idea or a new correlation of ideas, where the beauty of the abstract seems greater than the beauty of the concrete, then read Poincare, leisurely, sometimes dreaming, sometimes meditating, sometimes experimenting, but always thinking. Then the simplicity of the language, the dignity of the concepts, the inspirational suggestiveness of the thought may give you that permanent acquisition, a moment in which you live nobly and below which you may never sink as low as you have in the past. But beware, lest, having eyes, ye see not.
17. Science. March, 1912. *Organization of Knowledge.*

PHYSICS (P)

1. *Wireless Telegraphy.* Fortescue.
2. *The Atmosphere.* Berry
3. *Beyond the Atom.* Cox. These three belong to the pink series.
4. *Experimental Researches in Electricity.* Faraday. Notice the motto used as the frontispiece.
5. *Soap Bubbles.* Boys.
6. *Light, Visible and Invisible.* Thompson. This has a pleasing style, interesting contents and is easily understood.
7. *Surface Tension.* Willows and Hotschek.
8. *Electricity and Matter.* Thompson.
9. *The Electron.* Milliken.
10. *Sound.* Tyndall.
11. *Light.* Tyndall.
12. *The New Physics.* Poincare.